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VISION AND COLLEGE READING - A REVIEW OF THE LITERATURE AND REPORT OF A SURVEY.

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THE AMERICAN OPTICAL (AO) COMPANY'S SIGHT SCREENER, A PORTABLE BINOCULAR INSTRUMENT DESIGNED FOR MASS VISION TESTING, WAS EVALUATED AT THE UNIVERSITY OF MARYLAND READING AND STUDY SKILLS LABORATORY TO DETERMINE ITS CAPACITY TO IDENTIFY STUDENTS NEEDING PROFESSIONAL EYE EXAMINATIONS PRIOR TO READING INSTRUCTION. DATA FROM 106 PROBATIONARY FRESHMEN, AGED 18 TO 20, WHO WERE WEAK IN VERBAL SKILLS WERE USED IN THE EVALUATION OF VISUAL SUPPRESSION, VISUAL ACUITY, LATERAL MUSCLE BALANCE, VERTICAL MUSCLE BALANCE, DEPTH PERCEPTION, AND COLOR VISION. INCLUDED IN THE EVALUATION OF EACH SIGHT SCREENER TEST WAS (1) A DESCRIPTION OF THE TEST, (2) A COMPARISON WITH CLINICAL TESTS AND OTHER SCREENING INSTRUMENTS (KEYSTONE TELEBINOCULAR AND BAUSCH AND LOMB ORTHO-RATER), (3) SPECIAL PROBLEMS IN ADMINISTERING THE TEST, (4) GENERAL PROBLEMS IN TESTING THE PARTICULAR VISUAL FACTOR, (5) A DISCUSSION OF THE UNIVERSITY OF MARYLAND DATA AND COMPARISON WITH OTHER SURVEYS, AND (6) A DISCUSSION OF THE IMPLICATIONS AND APPLICATIONS OF THE RESULTS. RESEARCH ON THE RELATION OF VISUAL FACTORS TO READING SKILLS WAS EXAMINED. THE AUTHOR CONCLUDED THAT THE AO SIGHT SCREENER WAS A SATISFACTORY SCREENING TECHNIQUE FOR COLLEGE BECAUSE IT WAS RAPID, SIMPLE TO ADMINISTER, ECONOMICAL, AND DEPENDABLE IN MEASURING THOSE FUNCTIONS CONSIDERED IMPORTANT TO FORMAL VISION. TABLES, GRAPHS, AND A BIBLIOGRAPHY ARE INCLUDED. (LS)

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Vision for what? - the criterion problem:

Vision testing programs in industry and the military services are usually concerned with the establishment of standards for effective operation in a given visual task and the selection of personnel who meet these standards. Prediction of success in any job implies much more than estimates of the individual's visual efficiency. However, if seeing is a crucial part of the job, it is necessary to determine what is the minimum amount of visual efficiency needed to perform successfully in addition to knowing about the other significant variables. It goes without saying that a crane-operator probably needs both steropsis and distance acuity to perform adequately whereas the hosiery loop-twister must be able to see clearly at close distances. Likewise, in order to read, one must be able to distinguish the symbols on a printed page. All of these tasks involve other activities besides seeing, but before the other activities can occur, how well does the individual have to see? Crude measures are usually inadequate, but, on the other hand, precise measures of vision (17) are unnecessary for several reasons. Job-analysis techniques have not reached that stage of refinement where fine measures of vision would be required, so that screening, while coarse, is adequate. Freeman states, "Vision is the overseer and within the simple range of this duty need not be, and therefore is not, more complex than the muscular operations which it supervises...vision is the same for peeling potatoes as for splicing rope" (17).

Adequate vision for reading, however, involves more complex problems. If reading is "the reconstruction of the facts behind the symbols", as Korzybyski has defined it, the central brain process assumes paramount importance. As a matter of fact, most of the investigations of visual factors in reading boil down to the conclusion that one has to see to read in the usual manner, but the relationship ends there. Having tired of attempting to tease out neat relationships between visual problems and reading, the investigators in this field have turned their sights on the motivational variables and are prolifically producing papers on this more productive line of research (19,20). In scanning the current research on reading, one can run the gamut from a Neo-Freudian analyst's interpretation of reading difficulties in boys which he attributes to castration fears to the very significant work of Carmicheal (9) whose findings indicate the importance of motivation to visual fatigue factors in reading.

Let us examine some of the difficulties inherent in the visual aspects of reading. One of the most important is that of individual differences. Some individuals with very severe eye problems can, if motivated, compensate for their weakness and become excellent readers. Others with excellent vision are poor readers and correction of some minor defect (e.g., a slight muscle imbalance) may result in reading improvement (3,4). As Bannon (3) points out, "The improvement as a result of the correction of small errors of the refraction or muscle balance) does not mean that the neuromuscular effort necessary to compensate for small refractive errors is of itself the cause of poor reading. However, in a student with little skill, interest and motivation in reading, a slight neuromuscular effort results in conflicts, frustration and fatigue which make reading a discouraging task for him, and one which he easily puts aside as too difficult. In such cases, the correction of a slight refractive error may provide new hope and greater ease in reading, often resulting in improvement far beyond what is generally expected of low power corrective lenses."

Studies on the relation of visual defects and reading in the college population have generally found no significant relationship. Typical of such studies are the Dartmouth study (6), the work of Swanson and Tiffin (36), Carmicheal (19), and Stromberg (34). An earlier study at Smith College (23) in 1932 indicated that although a higher percentage of poor readers were near-sighted, a higher percentage of the good readers had both astigmatism and myopia. Probably these results reflect the fact that the college student population is a restrictive one and severe reading handicaps are less likely to be present or the students would not have been admitted. Also due to the increasing emphasis on the recognition and correction of visual defects in the elementary and secondary schools, students with severe or moderate defects are likely to receive help before they reach college.

Studies on grade school children have indicated more definitive relationships between ocular anomalies and reading -- particularly in the early school years. Fendricks (15) found that severly retarded readers showed lower visual acuity and astigmatism than normal readers. Morse and Peckham (23) found that reading improvement was significantly higher for children whose eye defects were corrected than normal sighted children over a year period. However, with the college group, mere correction of visual defects usually does not significantly effect changes in reading according to the Dartmouth study (6).

Also crucial to the discussion of the criterion problem is the question of the measurement of reading. Speed of reading (usually expressed in words per minute) and comprehension (as measured by a set of objective questions on the material read) are the generally accepted measures of reading effectiveness. "Some years ago it was felt that comprehension and rate of reading were rather highly correlated but more recent studies indicate absence of a high correspondence"(4). Since most reading tests are timed, the rapid reader usually ends up in the "good reader" group. College reading improvement courses generally emphasize improvement in rate of reading, and remarkable changes in speed of reading can occur in a few weeks' time. However, reading speed has been shown to vary with an infinite number of factors including set, background information of the reader, difficulty of the material, vocabulary, temperature of the testing room, illumination, humidity, background music, fatigue, interest of the reader, etc., etc. Also Glock has reported tremendous individual differences, with some students reading 18,000 words per hour faster than others on the same material (19). Comprehension tests vary tremendously in emphasis and difficulty, and are not always reliable indicators of how much the individual has learned from reading. An individual's comprehension will depend on his familarity with the topic, interest and vocabulary and many other factors. Hence variability in these criterion factors may contribute to the low correlations with visual measures.

<u>The problem of referral</u>:

The aim of any school vision screening program is to identify those individuals who need professional help. Basically, screening is an attempt to predict the outcome of complete eye examinations. As the result of screening, individuals are classified into two groups-- those who pass and those who fail. It is predicted that those who fail the test are in need of professional eye diagnosis, and those who pass are not. Leverett (22) has discussed at length the problems of under and over-referral in a school testing program. He suggests that the optimal screening situation is one in which

errors of over and under-referral are balanced, and neither of these ignored or over-emphasized. This implies that the screening device must be reliable and highly correlated with the clinical diagnostic instruments used by the ophthamologist. Perfect prediction can never be achieved as there are eye defects which cannot be revealed in a screening test but will be recognized in a complete eye examination. One of the complaints of users of the telebinocular is that cases referred to eye specialists on the basis of deviations indicated on the telebinocular are found not to need corrections -- thus over-referrals with this instrument are a problem.

Referral standards in a screening program should be set up under the aegis of an ophthamologist since although a screening test is not diagnostic, the interpretation of it involves "pre-diagnosis" which should be the function of a professional vision specialist.

In addition to vision test scores, subjective complaints and symptoms deserve some mention as possible referral criteria. The lay person generally assumes that headaches, eye fatigue and blurred vision, etc. are indicative of visual defects. The Dartmouth study reveals that the most frequent eye complaints are fatigue in reading, headaches, blurred vision and ocular discomfort. One-third of the subjects with normal and minor defects reported symptoms and there was no close relationship between symptoms reported and degree of defect. Symptoms were associated with moderate degrees of defect more frequently than with severe defects. Also, the individual responded to his eye problem in a way compatible with his general motivational pattern rather than expressing symptoms which might be classified as characteristic of a particular defect.

VISUAL SCREENING

The American Optical Company's Sight-Screener is a portable, binocular instrument designed for mass vision testing. It measures visual efficiency, indicating types of visual deficiencies, but it is not a diagnostic test. Seven different areas of vision are represented in the tests for near and distance vision, and special color plates are provided for a separate check on color vision. The sight-screener tests suppression, visual acuity for right eye, left eye, and both eyes, depth perception, and vertical and lateral muscle balance.

Our interest in the sight-screener stems from the need to install a vision screening program for the recognition of vision problems of college students who seek help from the Reading and Study Skills Laboratory of the University of Maryland. This paper represents an attempt to evaluate the adequacy of the sight-screener as a device to reveal those students who most obviously need professional eye examinations prior to attempting reading training.

The sight-screener is a relative newcomer on the market of visual screening instruments, its main competitors being the Bausch and Lomb Ortho-rater and the Keystone Telebinocular. The ortho-rater has been widely accepted in industrial and military vision screening programs and is backed by a considerable body of research. The telebinocular has achieved wider acceptance in school and college vision testing programs. (See Table I). Mr. Bannon of the American

Optical Company, in a personal communication, informs us that although the sight-screener has been used by industry and the military services for several years, only recently has it been used in schools and colleges. Norms for the college population on this instrument are not yet available.

The major selling-points a portable screening device has over other instruments in mass testing include:

1. It requires less space than standard clinical tests.
2. Subjects may be tested at their place of work or any convenient location.
3. The illumination on the test object is constant insuring stability of testing conditions.
4. The opportunity to memorize tests is eliminated since the subject cannot see the eye charts prior to testing.
5. A series of tests can be given in a short period. (The sight-screener averages just five minutes.)
6. A permanent record can be made easily which only the operator can translate into clinical terms.
7. The tests can be administered by a trained technician and results interpreted later by a professional eye specialist.
8. The test is less expensive to administer than individual eye examinations.

All three of the screening tests mentioned appear to be equally satisfactory in all respect to these points.

General Problems in Vision Screening

An adequate screening test, in addition to being rapid, simple, economical, and dependable, must represent the several different functions underlying visual performance. The tests included in the sight-screener target represent those areas of vision which are considered the most significant and testable by vision specialists today (17). However, seeing involves perception, and the organization of vision is quantitatively and qualitatively different than the sum of acuity, stereopsis, etc. As Freeman (17) writes, "A cold screening report no more represents vision than a schedule of materials represents a motor in operation." A lay person is incapable of understanding the inter-relations of these visual factors so that interpretation of these tests should be done by a vision specialist (17, 25, 22).

Certain types of vision anomalies are not revealed by the sight-screener and some of these have been shown to be related to reading difficulty. For example, we tested a person with severe astigmatism uncomplicated by myopia who scored in the normal range on all tests without glasses, but who has to wear thick-lensed glasses in order to read comfortably. Aniseikonia[1], a condition in which the retinal images formed by the two eyes are unequal in size or shape or both, has only been recognized in the past twenty years and may be a factor in reading difficulties (6,3,4). Small differences in the size of ocular images require that the individual make a constant effort to maintain binocular vision, and the adjustments required in reading frequently result in headaches or other symptoms (6). Some individuals with this condition do not

[1] The Dartmouth study suggests that this may be a common condition in that some degree of aniseikonia was found in 50% of the students tested.

persist in reading because of the frustration and effort required. A large degree of aniseikonia usually results in the suppression of one eye (3). This condition does not affect visual acuity and is not easily detected, however instruments have been devised for measuring it and diagnostic facilities are available in most larger cities. Investigations on the relation between aniseikonia and reading difficulty are being conducted at the Dartmouth Eye Institute and at the Harvard Psycho-Educational Clinic (3).

Let us turn our attention now to an evaluation of the sight-screener sub-tests and their application to a college vision testing program. As part of this evaluation, the results of a survey of 106 college freshmen at the University of Maryland will be included. This particular sample has some rather distinctive characteristics. The students represented are all probationary students who would not normally have been admitted to college because of deficiencies in their high school records. This group differs significantly from the normal college freshman group in that they have lower scores on the ACE Psychological Examination, the Cooperative Reading Test and the Cooperative English Test. They do not differ from regularly admitted students in respect to mathmatical achievement. Essentially they are weak in verbal skills and are more likely to have severe reading problems than ordinary college students. For this reason, we feel that there is a better possibility of finding clearer relationships between eye conditions and school work or reading than other studies have found with students who are generally of higher academic calibre (e.g., the Dartmouth study dealt with seniors.) Motivational factors have been found to be significant in predicting eventual college success with this group (38, 37). The age range of the students tested was from 18 to 20, and the figures in Table II represent maximal present vision, as students were tested with glasses on if their eyes had been corrected.

Our approach in evaluating the sight-screener tests includes:

1. a description of the test
2. comparison of the sight-screener test with clinical tests and other screening instruments
3. special problems, if any, in administering the test
4. general problems in testing the particular visual factor
5. a discussion of the results of our survey and comparison of our results with those obtained in other surveys
6. a discussion of the implications and applications of the results of the particular test

SUPPRESSION TEST

Description of the test: This test indicates whether the subject tends to suppress one eye, the defective eye, while appearing to use both. The right eye sees the letters KR within the top half of a double-lined circle. A subject with normal binocular vision should see DR directly above XB within a double-lined circle. In cases where the subject sees KR and XB alternately, the test is scored for alternate suppression. In our series, none of the students reported alternation, but some described partial suppression which is a more common condition (3), but not mentioned in the sight-screener scoring key.

Results and comparable studies: Eight per cent of our group showed suppression of one eye on the distance test and four per cent showed suppression on the near-point test. All but one of the subjects showing single vision showed suppression of the left eye which agrees with the higher frequency of below average acuity scores for the left eye. (See graph in appendix.) Wilson and McCormick (39) found that suppression was the least common deficiency in the analysis of sight-screener records of 10,000 workers. They found a general increase of suppression with age, and their results indicated that it was a more common symptom of males (10%) than females (1.8%). However, for the youngest group they tested (age 21-30), the percentages were 2.3% for males and .9% for females, which are lower than our figures.

Implications: Functional blindness in one eye as indicated by the sight-screener test is not generally amenable to correction by lenses (39). Some progress has been made in improving the efficiency of binocular vision through orthoptics (eye-training exercises), but this training is slow, expensive, and not always effective (19). Binocular vision is not an essential prerequisite for effective reading skills, for many people can compensate for extremely poor binocular vision, and one-eyed people can read. However, the person who has a severe reading difficulty and poor binocular vision may make faster progress with remedial reading help if he has eye training exercises as well, but eye-training itself will not improve his reading (3). The percentage of reading problem cases referred for orthoptics appears to vary with the personal bias of the reading specialist. Park (26) felt that 52% of his students with reading problems need eye-training while Robinson and Rychener (30) felt that orthoptic work was indicated in only 10% of the reading cases. We discussed this problem with an optometrist who was convinced that deficient readers with normal vision made faster progress in reading training if they had prior eye-training than without such training. Renshaw's early work (28) indicated that air force officers who were "normal readers" made significant gains in reading speed following eye-training without special help in reading. Manolakes (24) in an experiment with better controls compared two groups of adults enrolled in a marine corps speed reading course. He found that the experimental group, which received eye-training and reading help, made significantly lower gains in speed of reading than the control group who received no eye-training. There were no significant differences between the groups in respect to eye movements at the conclusion of the experiment. We suspect that most of the gains reported in reading ability as a result of the use of mechanical devices for eye-training can be accounted for on the basis of the motivational appeal of the devices. Many college reading programs admit that the use of these instruments is primarily for motivational purposes. (See Table I)

One other problem in the administration of the sight-screener suppression test deserves consideration. Stromberg (34) has reported evidence that the time element is important in this task and that if the subject is allowed to stare at the test object for a long period, he will eventually experience fusion. This can easily be controlled on the sight-screener if the operator is alert.

VISUAL ACUITY TESTS

Description of the tests: The sight-screener visual acuity tests consist of 28 non-serif letters graduated in size from large to small and divided into groups of four letters. The last two groups of letters corresponding to 20/15 and

TABLE I

Mechanical Devices Being Used in Study Skills College Programs and Purposes for Which Devices are Used

	PURPOSE		
Device	Diagnosis	Motivation	Remediation
Telebinocular	22.9%	8.4%	1.2%
Ortho-rater	3.6	--	--
Metronoscope	--	8.4	6.0
Tachistoscope	8.4	39.7	48.2
Accelerator	6.0	48.2	55.4
Rate Controller	--	21.7	28.9
Harvard Films	2.4	38.5	44.5
Audiometer	3.6	--	--
Flash Quizzer	--	2.4	1.2
None	14.5	14.5	14.5

* Adapted from Bamman, Henry J., Study Skills Program - Stanford University, Unpublished Ed.D Dissertation, 1952.

Description of the tests: (Cont'd.)
20/10 visual acuity scores, are located on the second line. The criterion for passing is recognition of two out of the four letters in a group. There are different tests for the right eye, left eye, and both eyes; but the distance and near vision series are identical.

Comparison with other tests: Numerous tests have been devised for the measurement of visual acuity including letters, rings, ruled gratings, checkerboards, fine wires suspended in space, and, for children, pictures of familar objects. The Landolt Rings (broken circles) have been accepted as the international standard measure of acuity, but the most commonly used test in practice is the Snellen letter chart. Sloan (33) in a critical review of visual acuity problems stated that the best test object is "familar and suitable letters of equal legibility without serifs." Sloan, Rowland and Altman (32) compared acuity ratings of subjects tested on the ortho-rater with three targets and concluded that letter-types and Landolt rings may be considered equivalent in mass testing programs, but the checkerboard target (ortho-rater's illiterate test) gave significantly different acuity scores than did the ring and letter tests. They also stated that there were differences in the ease of reading of the various letter types -- Z being the easiest to read, and S the hardest with D, C, and S being more difficult than the straight line letters.

The sight-screener acuity tests are very similar to those of the ortho-rater. The major difference is in the grouping and arrangement of the letters. The ortho-rater has one line of letters for each test, whereas on the sight-screener the last two groups of letters are on a second line. Davage and Summer (12) studied perception threshold as a function of isolation of Snellen lines and found that there is a 15-20% increase in acuity over the ordinary Snellen when the lines are isolated; therefore, one would expect higher acuity ratings on the screening instruments. It has also been reported that the acuity is higher when letters are spaced widely. Whether the differences between the targets in the two machines are great enough to show these kinds of effects is problematical in view of the comparable results which have been obtained. However, it has been our experience that some subjects who have excellent visual acuity do not attend to the small letters at the bottom and may ask on the second series of acuity tests whether they are supposed to read the second line which they saw clearly on the first series, but did not bother to read. This may affect the accuracy of acuity scores higher than 20/20.

Some of the general problems concerned with letter type acuity scales include problems of validity and units of measurement. Sloan (33) states that the Snellen scale is not an accurate measurement of degree of myopia and that the scale gradation between 20/20 and 20/100 needs more investigation as these do not correspond to "dioptric differences in errors of refraction." Colenbrander (10), concerned with the validity problem, has suggested that a more valid measure than the conventional Snellen fraction would be "the square root of the measured visual acuity written in decimal form." Despite the inadequacies and imperfections of the Snellen scale, it is the most commonly used and most easily understood measure. Changing the standards of measurement would necessitate mass re-education. However, it probably behooves those concerned with vision screening to be aware of the inadequacies of the present acuity measurement system.

The sight-screener, telebinocular and ortho-rater simulate distance targets by compensating lenses. One possible disadvantage of these devices is that the subject's awareness of the actual nearness of the test object might result in accommodation for a closer distance than the optic distance, hence

acuity ratings would be lower than when tested at an actual 20 foot distance (1). This has been checked experimentally by several investigators (1, 11). Cook (11) in a previous study found the ortho-rater acuity higher than the standard wall target at true distance and the sight-screener acuity slightly lower than actual distance target, but was not able to come to any final conclusion. Rowland and Altman (1) found a correlation of .935 between acuity scores on the ortho-rater and actual 20 foot-distance target of the same type. Subsequent studies on the same problem of distance simulation on the phoria tests indicate that correlation between the same test targets at simulated and true distances are as high as test-retest correlations, hence there is no problem.

In an unpublished study, 100 army subjects were tested on the sight-screener distance acuity tests and the Armed Forces Distance Acuity Tests and the acuity ratings obtained showed little difference.

Another problem involves the necessity for testing both eyes together for acuity. Sloan (33) states that if eyes are tested separately it is not necessary to check acuity on both eyes together. Our findings indicate that acuity for both eyes may be higher than the rating for either single eye, but it was never lower than the best acuity rating for a single eye. Therefore, whether acuity scores for both eyes are necessary seems to depend on whether the purpose of screening is to disclose individuals with poor acuity or to select those with normal or better acuity.

Results of our survey and comparable studies: There are many problems involved in comparing the statistical results of acuity findings from one survey to another. Some of the significant variables include age, nature of the sample (e.g., eye patients, industrial workers, pilots, etc.), whether subjects were tested with or without glasses, type of acuity test used, and even the criterion for passing the same test -- e.g., some investigators determine acuity on the basis of the last letter passed before one failure, and others use the last letter passed before two failures as a base. When acuity results are expressed in terms of sufficient and inadequate vision, the limits of adequate acuity will vary from 20/20 to 20/40 depending on the study.

The results of our survey are not significantly different from those obtained in a study of sight-screener records of 100 army personnel (age unspecified and corrections unspecified) in respect to proportions with 20/20 or better distance acuity (11).

In general our results indicate that the college group tested has normal or better acuity. There is a tendency for the group to have higher near visual acuity than distance and poor vision in the left eye. In comparison with the Dartmouth study (6) (see Table II), our students are more likely to have 20/30 acuity than their group, but poorer acuity scores are rare in both groups, indicating that severe errors in refraction have been corrected.

Implications and other problems: Several studies concerned with acuity factors and reading have been mentioned above (34, 8). One of the common beliefs is that excessive reading will ruin one's eyes. It is felt that college students particularly will show acuity decrements as a function of performing the reading necessary for the pursuit of a college degree. Parnell (27) in a study of the visual acuity of Oxford undergraduates concluded that their vision was four times

TABLE II

Comparison of U. of Md. and Dartmouth Results of Distance Acuity Tests

	RIGHT EYE			LEFT EYE		
	Dartmouth		U. of Md.	Dartmouth		U. of Md.
	Corrected	Uncorrected		Corrected	Uncorrected	
20/15	52%	40%	32%	54%	39%	26%
20/20	44	26	52	41	28	41
20/25	2	4	N.A.*	2	3	N.A.
20/30	2	5	17	1	7	29
20/40	0	4	0	1	3	1
20/60	0	5	N.A.	1	5	N.A.
20/70	0	2	0	0	2	0
20/100	0	3	0	0	4	1
20/200	0	11	0	0	9	1

* N.A. means not applicable

The Dartmouth study included 636 students; the U. of Md. study, 106.

worse than a non-college population of the same age, and that acuity decreased, but at a slow rate, during the four years of college. Carmicheal (9) in his study of visual fatigue obtained some intriguing results that bear on this problem. He found no significant changes in acuity for subjects tested before and after a six-hour reading period. In fact, there was a tendency for acuity scores to be higher immediately following the reading period. This rise in acuity was quite pronounced on the Keystone test, and Carmicheal concludes that there were no demonstrable fatigue effects in acuity following prolonged reading. This might suggest that if acuity changes over time do occur in college students, one might more profitably look for the causal factors in the external environment (e.g., illumination inadequacies) or motivational causes rather than the reading activity itself.

LATERAL MUSCLE BALANCE TEST

Description of the test: The sight-screener uses polaroid to present dissimilar images to the two eyes in the phoria tests. The left eye sees an arrow, and the right eye sees a series of dots calibrated in units of 1 prism diopter. Orthophoria (normal muscle balance) of zero prism diopters on the sight-screener corresponds to an optic esophoria of 1.7 prism diopters. Deviations in either direction (esophoria or exophoria) can be expressed in units as fine as 1 prism diopter by using unnumbered alternate dots as well as numbered ones. The tests are identical for near and far point distance; far-point distance is simulated by means of compensating lenses and reading distance is an actual 14 inches from the subject's eyes.

Comparison of the sight-screener phoria test with clinical and other phoria tests: On the orthorater test for muscle-balance (lateral), the right eye sees a row of numbered white spots and the left eye views three white spots and an arrow. Solan and Rowland report that the arrow remains steady and exactly in line with one of the spots seen by the right eye, because three white spots are seen by the left eye (31). In our study with the sight-screener we found that although subjects were told told to give their first impression of the location of the arrow, they became quite disturbed by the fact that the arrow shifted around so that it was usually necessary to have them close their eyes and/or look away from the machine before trying to get a response. This was particularly true on the near phoria test. It would seem to us to be less unnerving to the subjects, and more acceptable, if the arrow appeared to remain relatively fixed.* However, this does not seem to affect the efficacy of the test on the basis of the experimental evidence.

Several studies have been made which compare the sight-screener and orthorater and clinical instruments designed to measure lateral muscle balance. Table III summarizes the results of these studies. Sloan and Rowland in a carefully controlled experiment tested 150 subjects on three clinical tests and the orthorater and the sight-screener. They concluded that the sight-screener correlated as highly with clinical instruments as these do with each other. The reliability coefficient of the sight-screener (.98) obtained by Sloan and Rowland is as high as those obtained on the ortho-rater and clinical tests. Table IV summarizes the test-retest correlations found by different investigators. The higher results obtained by Sloan and Rowland may be attributed to more careful experimental conditions and greater similarity between the three clinical tests used and the screening devices' targets. The validity coefficients for near lateral phoria tests on both the sight-screener and the ortho-rater are lower than the distance phoria tests. The investigators recommend that the near phoria test be administered several times and the results averaged to insure an accurate appraisal of this factor.

*That is, the measurement is taken after the arrow comes to rest rather than having the subject report arrow's position after occluding the right eye.

TABLE III

Intercorrelations of Phoria Tests*

	Wirt	Davis	Imus	Sulzman Cook & Bart.	Sloan & Rowland
Far Lateral					
Clinical & Ortho-rater	.76-.84	.53	.70	.56	.88-.91
Clinical & Sight-screener	-	-	-	.37	.86-.92
Clinical & other clinical	-	-	-	.74	.82-.95
Sight-screener & Ortho-rater	-	-	-	-	.88-.92
Near Lateral					
Clinical & Ortho-rater	-	.64	.77	.67	.66-.79**
Clinical & Sight-screener	-	-	-	.54	.82-.86
Clinical & other clinical	-	-	-	.70	.82-.86
Sight-screener & Ortho-rater	-	-	-	-	.72-.76

**Sloan and Rowland attributed the lower correlations obtained between the ortho-rater and clinical tests to a defect in the target and repeated the tests on 50 additional subjects finding correlations from .65 to .80, however, they felt that these correlations were lower in all tests because the sample contained fewer persons with severe defects than the original sample.

TABLE IV

Test-Retest Correlations*

	Investigator		
	Imus	Sulzman, et.al.	Sloan & Rowland
Far Lateral			
Clinical Test	.81	.79	.94-.98
Ortho-rater	.87	.87	.98
Sight-screener	-	.80	.98
Near Lateral			
Clinical Test	.90	.87	.93-.94
Ortho-rater	.81	.92	.98
Sight-screener	-	.83	.94

*Both tables revised and adapted from Sloan and Rowland, "Comparison of Ortho-rater and Sight-screener Tests of Heterophoria with Standard Clinical Tests," Am Jo Ophth., 34:10, October, 1951.

Comparison of the sight-screener phoria test with other tests:(Cont'd.) Wirt (40) found significant differences in the direction of esophoria occur when a phoria test is immediately preceeded by a test involving binocular fusion. On the sight-screener the phoria tests follow the test for depth perception which involves fusion. It is therefore recommended that the order of presentation of tests by altered so that this disadvantage be eliminated if reliable results on the muscular balance tests are desired.

General problems in testing muscle balance: Muscular imbalance is considered the main physiological condition that prevents coordination of the eyes in binocular vision (19). Exophoria refers to the tendency of the eyes to turn out; esophoria or over-convergence refers to the eyes turning inward. Orthophoria, or normal muscle balance is a convenient term for very slight deviations, since if measuring instruments were precise enough, small deviations would always (6) be found. Distance phoria tests measure the "tendency of the eyes to converge or diverge from the near point of fixation when fusion is interrupted"(6). Near lateral phoria is a different kind of function. In near tests, exophoria is expected because of the anatomical fact that the eyes are separated. Bender, et.al. (6) have classified degrees of heterophoria according to prism diopter deviations from the normal. (See Table V). Deviations from 2-7 prism diopters in the direction of exophoria were considered negative, and deviations from 0-1 and also from 8-11 prism diopters were classed as Grade I defects. This mode of classifying phoria scores was not used in any of the industrial surveys using the sight-screener, and is an important consideration in setting visual standards for near-point testing.

Comparison of U. of Md. study and other surveys: Some investigators (3, 4) have concluded that convergence insufficiency is the most common eye difficulty associated with reading disability. However, it remained for Bielschowsky (7) in 1936 to report that near-point muscle imbalance is found in at least 80% of thousands of persons with normal vision. Subsequent surveys have substantiated this. The Dartmouth 1940 survey revealed that 56% of the students tests showed exophoria and 36% had esophoria. The high percentage of exophoria found in this group was, the author feels, related to the frequency of other anomalies characteristic of their particular sample. Our findings showed a lower percentage of students with esophoria (14%) with 46% showing exophoria. Bemis (5), in the industrial survey cited, found some degree of exophoria in 75% of the workers, esophoria in 26% and 9% with "normal" balance. The Dartmouth group concluded that young, healthy subjects can readily compensate for slight convergence difficulties. However, there remains the possibility that in individual cases, moderate degrees of muscular imbalance can interfere with the development of adequate reading skills.

VERTICAL MUSCLE BALANCE TEST

Description of the test: The sight-screener test for vertical phoria consists of a vertical row of dots exposed to the right eye, and a horizontal straight line viewed by the left eye. The subject is asked to report how many dots he sees above the line. Deviations can be calibrated in units of one-half prism diopter, and the test result is classified as orthophoria (normal) or left or right hyperophoria (depending on which eye deviates).

TABLE V

Detailed Clinical Diagnosis of Heterophoria for Distance and Near Vision*

(Bender, et.al. "Motivation and Visual Factors")

Type of Heterophoria	Percent of Subjects with Degree of Defect			
	Negative	Grade 1	Grade 2	Grade 3
Exophoria, Distance	(1-3 diop.)**	(4-6)	(7-10)	(>10)
249	97	1	1	1
Esophoria, Distance	(1-2)	(3-4)	(5-8)	(>8)
161	86	7	3	4
Hyperphoria Distance	(< 1)	(1-2)	(2-3)	(>3)
Exophoria, Near	(2-7)	(0-1) (8-11)	(12-15)	(>15)
338	58	39	1	2
Esophoria, Near	(c)	(0-2)	(3-6)	(>6)
108	0	57	34	9
Hyperphoria, Near	(<1)	(1-2)	(2-3)	(>3)
166	84	14	1	1

*Not shown is the number of cases of orthophoria (32 or 7%)

** The classification of degree of defect in terms of variation in diopters included here represents an attempt to formulate standards for diagnosis since, according to the authors, generally accepted authoritative standards do not exist.

Comparison with clinical instruments: Sloan and Rowland (31) concluded that the sight-screener and ortho-raterwere as effective as clinical instruments in detecting significant deviations of hyperphoria. All of the instruments, including the clinical tests, occasionally failed to detect a moderate degree of near-hyperphoria. For this reason, the authors recommend that several checks be made to improve the accuracy of the results.

General problems and comparison of survey results: Hyperphoria refers to the tendency for one eye to turn up in binocular convergence. Severe deviations of hyperphoria occur but rarely in the general population (6, 3, 31). The Dartmouth study indicated that although 33% of the students showed some hyperphoria, 99% of these deviations were negative or of first degree, hence unimportant. Bemis (5) found that 73% of the workers tested showed orthophoria at distance and 71% at near-point with 90% of all cases falling within a range of 1/2 prism diopter from orthophoria. Our findings indicate that 68% of the students had normal balance at distance and 65% at near-point with no students showing extreme deviations.

Since this condition is a rare one and the evidence suggests that most individuals can compensate for slight variations in vertical balance, we feel that its implications for reading are limited except in cases with extreme deviation.

DEPTH PERCEPTION TEST

Description of the test: The sight-screener stereopsis test consists of 5 groups of 5 circles each presented to both eyes. If the subject tested has normal depth perception one of the five circles in each group will appear to "float out" as a result of the fusion of slightly disparate images. If the subject fails to see the "displaced circle" on the first trial, he is shown a plastic demonstrator and asked to try again. If he fails this time, the test is discontinued. The subject's score (number right before first failure) is converted to percent of stereopsis using the Shephard-Fry Scale.

Comparison with other tests: Fletcher and Ross (16) in a review of stereoscopic vision tests concluded that the ortho-rater is the most adequate of the commercial screening devices for measuring depth perception, and is as good as any of the available clinical tests. They note that the sight-screener and telebinocular steropsis tests have received lower ratings in comparative studies.

Our results and comparative surveys: Bemis (5) in an industrial survey found that of 823 persons tested 56.9% had 105% stereopsis with 25.1% having 0%. The bimodal distribution is undoubtedly a result of the instructions as generally used. We found that 53% of our students demonstrated 105% steropsis closely agreeing with Bemis' results. Wilson and McCormick (39) in another industrial survey found that depth perception deficiency as measured by the sight-screener was the most prevalent of the uncorrectable eye problems. Of the males, 29.6 and of the females 29.4 they tested exhibited this. Their cutting-score for deficiency was 75% on the Shephard-Fry Scale. Using their criterion, 23% of our group would be judged deficient in depth perception. Depth perception ability apparently weakens with age and since ours was a younger population, differences are probably not significant.

Implications and problems: There is little relation between depth perception and reading skill except that both involve binocular fusion. The sight screener test is tricky to administer because many subjects do not seem to understand the task even when the plastic demonstrator is used. Frequently they will "catch on"

during the administration of the near stereopsis test, and repetition of the distance test will result in higher scores. The instructions are not clear as to whether the test should be stopped after the subject has passed two groups and failed the third. The groups are not graduated in difficulty and we found that subjects will get groups 1, 4 and 5 correct. Some subjects will try to guess their way through the task. This is probably the least satisfactory of all the tests in the sight-screener series and the most meaningless for our purposes.

COLOR VISION TEST

Description of the test: The AO Color Vision Test consists of 18 Pseudo-Isochromatic Plates which are administered following the instrument tests. This type of color test remains the most popular of the many pigmented tests for detecting color deficiencies. Color weakness is indicated if the subject fails one plate, and degree of defect is not related to the number of plates failed, although some users of the test have taken as the criterion of red-green blindness the failure of five plates. Farnsworth (14) corroborated the all-or-none instructions finding an insignificant correlation between severity of color defect and number of plates failed. He further noted that the AO color plates correctly classified 99% of a "young, educated population" in respect to color deficiency.

Comparable surveys and special problems: Accurate figures on the frequency of color deficiencies in the general populations are not available according to Geldard (18). He states that color weakness is fairly common" and that red-green blindness is "quite common," noting that red-green blindness has been found in as high as 8% of the male population in some surveys. Our findings that 36% of the group tested exhibited color weakness seem surprisingly large in comparison with other surveys. Also it seems unusual to find females with color weakness in view of textbook statements on the rarity of this condition (18). However, the Goodrich survey indicated that females were more frequently color deficient than males -- 18.2% of the females and 11.9% of the males showing this weakness. AO plates were used in this study, but their criterion for color deficiency was failure of two plates. Our subjects who returned for information on the results of the tests were asked if they had trouble distinguishing between colors. Those who had failed one plate often made statements like: "I've wondered about that because my uncle was color-blind" or "I have trouble telling the difference between new car colors," etc. These statements give some subjective confirmation to the test classification method we used. The Dartmouth study indicated that 10% of their group showed color deficiency, but do not indicate the scoring method used.

We observed that two subjects who, when tested without glasses, failed three or more plates, but, when tested with glasses, passed all plates. Because it is believed that an important feature of red-green blindness is retention of normal acuity, we wonder what might account for these changes. There is the possibility that the improved color discrimination with corrected acuity may be an artifact due to the nature of the test which involves discrimination of forms (numbers) as well as color. This problem may merit further investigation. Some optometrists have claimed good results in training color-deficient and red-green blind persons to pass tests of this type by using modified plates which vary the contrast between figure and ground.

The AO color test is an adequate, easily administered method of differentiating between color deficient persons and normal trichromats. Since the number of color weak individuals found in our study seems high in comparison with other surveys, it is planned that the tests be rescored using more stringent standards, and that additional groups be tested to see if these results might be a function of sampling error.

SUMMARY AND CONCLUSIONS

1. The AO sight-screener is discussed in respect to its adequacy for use in a college vision screening program. The sight-screener has only recently been used in school screening programs and norms for college populations are not available at present. Results of surveys which have been made with the B & L ortho-rater and the Keystone telebinocular are discussed.

2. The general problems of mass vision screening are considered including validity requirements, reliability, inadequacies of criteria available, referral problems, and prediction of clinical examination results.

3. The relation of visual factors to reading skills is discussed. Investigators have failed to find clear-cut, significant relationships between visual difficulties and reading ability on the college level. However, the consensus of opinion favors an approach where visual defects are identified and corrected prior to reading training since individuals are differentially affected by visual problems. Motivational factors in reading and in the individual's ability to compensate for his visual defects have been found more important than the nature or degree of defect. Some problems in the assessment of reading ability are described.

4. Sight-screener records of 106 college freshmen at the University of Maryland are presented. These results indicate that the majority of the group has above average acuity and measures of other visual factors corroborate the findings of other college surveys. This group showed a higher percentage of color weak individuals than other investigators have found and possible explanations are discussed.

5. The separate sub-tests of the sight-screener are described and evaluated. In general, the sight-screener tests correlate highly with other screening instruments and clinical tests. The following problems and recommendations are suggested:

A. In giving the test for suppression, the operator should limit closely the length of time the subject is allowed to view the target for most reliable results.

B. There is some question as to the accuracy of survey figures reported on this instrument for populations with higher than 20/20 acuity scores based on our experience in administering the test. The position of the letters on the test target raises this problem, however, generally high correlations have been obtained between this test and other screening devices.

C. The stereopsis test on the sight-screener is probably the least adequate of the series on the basis of comparable devices, and the least meaningful for our purposes.

D. Near lateral muscle balance is a variable phenomenon even on clinical tests. Investigators have recommended that several re-checks be made on this test and the results averaged for higher accuracy on the sight-screener. The cover method of presentation appears to have advantages in increasing the reliability of this test. Although the lateral muscle balance tests on the sight-screener have been found to correlate as highly with clinical tests as clinical tests do with each other, the above cautions should be observed to increase the predictive value of the test for individual cases.

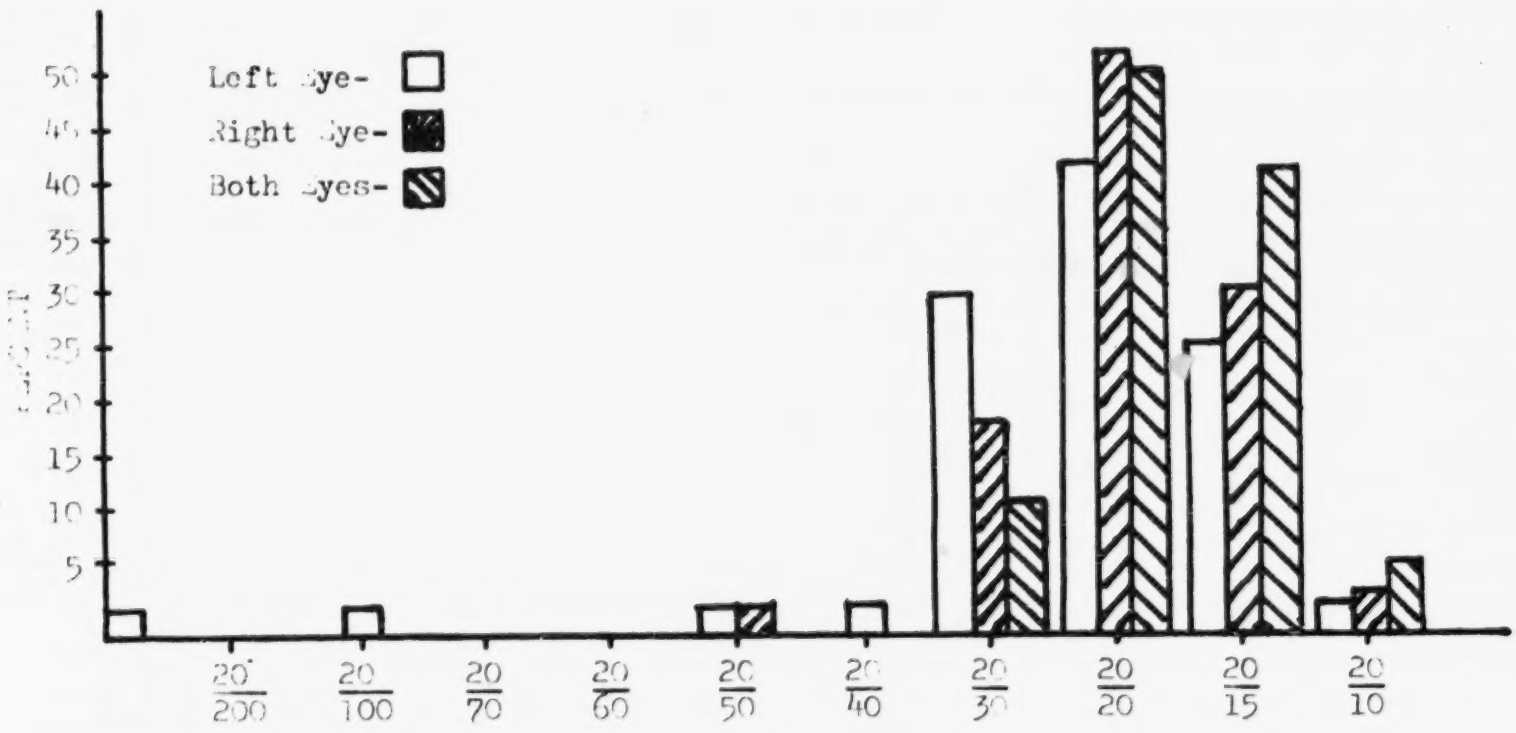
E. Vertical phoria results on the sight-screener are as accurate as those obtained on clinical tests. Severe degrees of vertical imbalance are rare, and none of the available instruments are foolproof in classifying moderate degrees of this deficiency. It is recommended that several checks be made when there is a question, and the results averaged for greater accuracy.

F. The AO color plates furnish a satisfactory screening technique for discriminating between color deficient persons and normals. Our findings suggest possible influence of acuity factors on color perception which is not explained by current evidence.

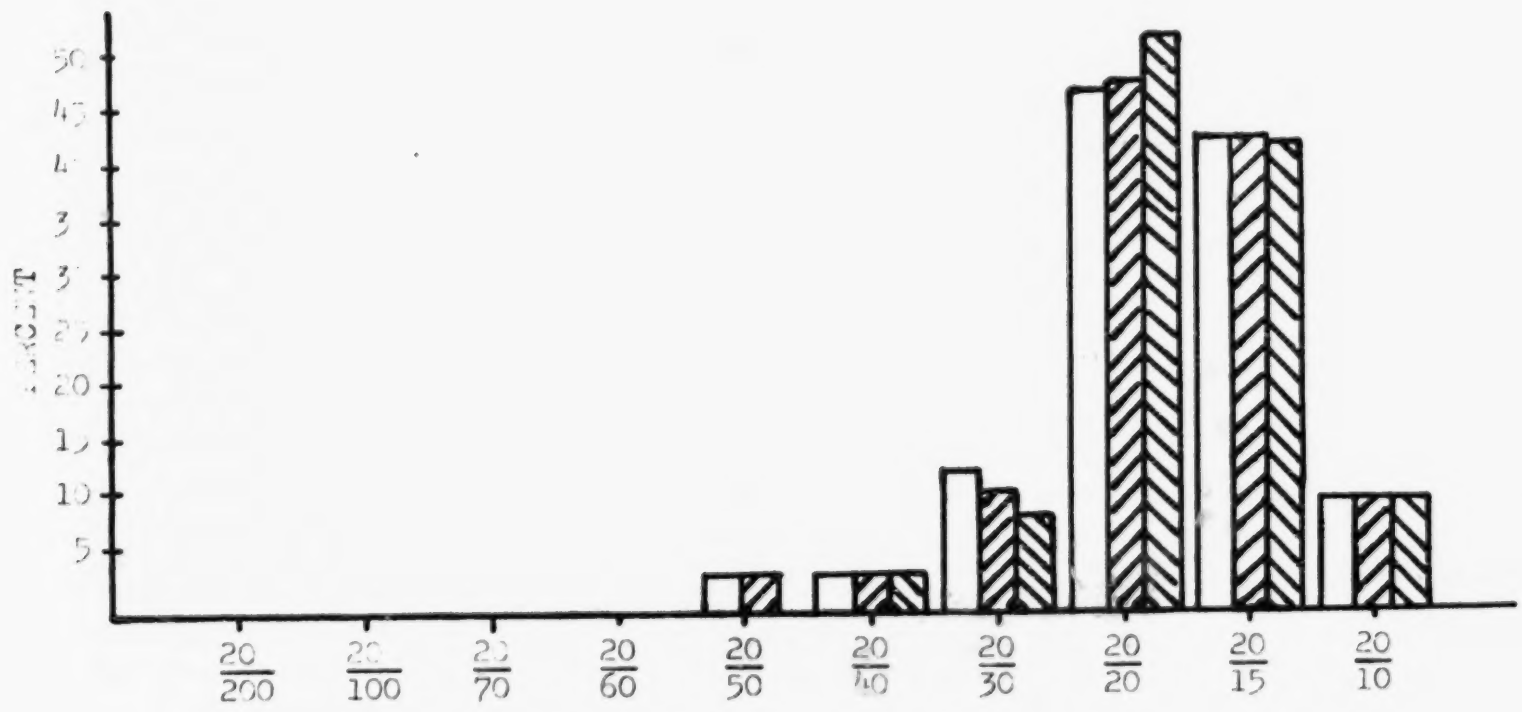
6. Conclusion:

The AO sight-screener meets the general requirement for a satisfactory screening technique for college use in that it is rapid, simple to administer, economical, dependable and measures those functions which are currently felt to be of importance in normal vision. The above cautions should be observed in utilizing the device. Studies have indicated little difference between the sight-screener and the ortho-rater on survey results obtained and correlations with clinical tests. These instruments can probably be considered equivalent except where the screening of depth perception is significant. In depth perception measurement, the orthorater has been found superior.

DISTRIBUTION OF VISUAL ACUITY SCORES OF COLLEGE FRESHMEN ON THE AO SIGHT-SCREENER (N-106)



FAR POINT VISION



NEAR POINT VISION

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